MODIS Semi-Annual Report
Snow and Ice Project
Reporting Period: January - June 1997
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## SUMMARY

During the first half of 1997, there was progress in a number of areas. First, we conducted successful field and aircraft missions in New Hampshire, New York and Wisconsin in collaboration with the University of Wisconsin and the WINCE project. In addition, we have worked on algorithm improvements that have resulted in an enhanced snow-mapping algorithm. A series of Web pages were constructed. Version 1 algorithm codes were delivered to SDST. There have been several papers written and presented at conferences. A paper on the sea ice algorithm is in preparation.

## Aircraft Experiment - February 1997 (D. Hall)

Field work was conducted in conjunction with the MODIS MAS Winter Cloud Experiment (WINCE) experiment in three different areas. Field measurements were conducted by D. Hall and Klaus Bayr and students from Keene State College in Keene, NH, in conjunction with a NASA ER-2 overpass on 10 February 1997. On 9 February 1997, MODIS Airborne Simulator (MAS) Data were acquired over central New York State as part of WINCE. During the overflight, Andrew Klein/USRA, Alex Moore and Carrie Brindisi of Hartwick College and Joan Ramage of Cornell University conducted a field survey of snow conditions in Hartwick College's Pine Lake ecological reserve. Prior to the overflight, arrangements were made with Landcare Aviation of Onedia, NY, to provide high resolution aerial photography of the study site. The field data and aerial photography will be used to validate the snow map produced from the MAS data using the MODIS snow-mapping algorithm.

## Algorithm Validation

### Improved Detection of Snow in Forested Conditions (A. Klein/USRA)

With the exception of cloud cover, the largest limitation to producing a global daily snow cover product using MODIS is the presence of a forest canopy as it both obscures and shadows the snow underneath. A Landsat Thematic Mapper (TM) time series of the southern BOREAS study area (SSA) in Prince Albert National Park, Saskatchewan was used to evaluate the performance of the current MODIS snow-mapping algorithm under varying forest types. A snow reflectance was used in conjunction with a canopy reflectance model (GeoSAIL) developed by K.F. Huemmrich (code 923) to model the reflectance of a snow-covered forest stand. Using these coupled models, the effects of varying forest type, canopy density, snow grain size, and solar illumination geometry on the performance of the

snow-mapping algorithm were investigated to better understand the influence of these processes on the performance of the snow-mapping algorithm (Klein et al., in review).

Using both the TM images and the reflectance models, two changes to the current algorithm are proposed that improve the accuracy of the at-launch snow-mapping algorithm in forested areas. These revisions include using the Normalized Difference Snow Index and Normalized Difference Vegetation Index in combination, to better discriminate between snow-covered and snow-free forests. A minimum threshold of 10% in the visible wavelengths is also proposed. This will prevent dense forests with very low albedo from incorrectly being classified as snow. These two changes increase the amount of snow mapped in forests during winter and decrease the area incorrectly identified as snow in summer. Comparisons of the current and revised snowmapping algorithms show that the accuracy of the revised algorithm is considerably higher than that of the original algorithm under the conditions found in the SSA (Klein et al. in press; Klein et al., in review).

In addition to improvements to the at-launch algorithm, other approaches to improved detection of snow in forests that could be employed in the post-launch timeframe are being investigated. At present, an approach suggested by Yoram Kaufman which builds on his strategy for aerosol corrections over forests (e.g. Kaufman and Tanre, 1996) is being explored. Preliminary results suggest that computationally -simple measures can be constructed that detect relatively small changes in pixel reflectance due to the presence of a snow cover beneath the canopy.

The major results of the study were (1) a combination of NDSI and NDVI should allow more accurate classification of snow-covered forests, and (2) a threshold in a visible wavelength should be used for coniferous forests in which the visible reflectance is too low to be considered snow-covered.

References

Klein, A. G., Hall, D. K., and Riggs, G.A. in press. Improving the MODIS global snow mapping algorithm. IGARSS'97.

Klein, A. G., Hall, D.K. and Riggs, G.A. in review. Improving snow-cover mapping in forests through the use of a canopy reflectance model. Hydrological Processes.

Kaufman, Y. J. and Tanre, D. 1996. Strategy for direct and indirect methods for correcting the aerosol effect on remote sensing: from AVHRR

to EOS-MODIS. Remote Sensing of Environment, 55:65-79.

## Results of the Alaska '95 Experiment (D. Hall)

Other algorithm-validation work showed that the current algorithm is capable of mapping snow cover in central Alaska when the vegetation-cover density is about 50% or less with an accuracy of about 94%, and when the vegetation-cover density is >50%, the accuracy drops to 71%. Overall, the accuracy of the snow-mapping algorithm is 85% for a 13 April 1995 MAS scene with a variety of land-cover types. These results come from the MAS data that were acquired in April of 1995 in central Alaska. It is hoped that with a modified algorithm, as described above, more snow will be mapped in forests with densities of >50%, and that the accuracy of snow mapping will improve accordingly. A paper on this topic has been accepted for publication in Annals of Glaciology, and a copy is attached to this report.

## Algorithm Delivery (G. Riggs/RDC and H. Powell/GSC)

George Riggs and Hugh Powell delivered to the MODIS Science Data Support Team (SDST) Version 1 algorithm codes and supporting files for the MODIS snow and sea ice data products. They began with writing Version 2 specifications and algorithms for the MODIS snow and sea ice data products in the new HDF-EOS format for EOSDIS. A preliminary Version 2 data product file specifications file was submitted to SDST.

## WEB PAGE (D. Hall)

A Home Page and associated Web pages were developed for the MODIS snow and ice project and constructed by Meg Larko/GSC. The address is: http://ltpwww.gsfc.nasa.gov/MODIS_Snow/modis.html

## Sea Ice Algorithm (G. Riggs/RDC)

A paper describing the MODIS sea ice detection algorithm is in preparation. In the paper, usage of the MODIS cloud mask algorithm and data product are described. Some results are shown using MODIS Airborne Simulator (MAS) data from the April '95 campaign.

A group of Interactive Data Language (IDL) procedures that is used to support development and analysis of the MODIS snow and sea ice mapping algorithms and data products were developed and refined. These procedures facilitate examination and investigation of data product inputs and outputs for scientific analysis and for conformance to product specifications. They also support quality assessment (QA) of the data.

The MODIS cloud mask algorithm and resulting cloud mask for a MAS scene of sea ice was applied and analyzed. In depth investigation of the processing paths within the cloud

mask algorithm and cloud tests applied was carried out. Analysis of the cloud mask is an ongoing collaborative effort with Dr. Steve Ackerman (University of Wisconsin) of the cloud-mask team. Analysis was included in the draft of the MODIS sea ice algorithm paper being prepared.

## PUBLICATIONS AND PRESENTATIONS

### In press:

Hall, D. K., J.L. Foster, A.T.C. Chang, C.S. Benson and J.Y.L. Chien, in press: Determination of snow-covered area in different land covers in central Alaska from aircraft data - April 1995, Annals of Glaciology.

Polissar, A. V., P.K. Hopke, P. Paatero, Y.J. Kaufman, D.K. Hall, B.A. Bodhaine and E.G. Dutton, submitted: Long-term trends and seasonal variations of aerosol concentration at Barrow, Alaska, Journal of Geophysical Research.

### Submitted:

Klein, A., Hall, D. K., Riggs, G.A, Improving snow-cover mapping in forests through the use of a canopy reflectance model, Hydrological Processes.

Klein, A., Hall, D. K., Riggs, G. A., Improving the MODIS global snow-mapping algorithm, Proceedings of IGARSS '97.

Scharfen, G. R., D.K. Hall and G.A. Riggs, MODIS snow and ice products from the NSIDC DAAC, Proceedings of the SPIE Conference, 27 July - August 1, 1997, San Diego, CA.

### In preparation:

Riggs, G.A. et al., Sea ice identification with the Moderate Resolution Imaging Spectroradiometer Airborne Simulator (MAS).

### Presentations:

Hall, D. K., "The MODIS global snow-mapping algorithm," University Courses on Svalbard (UNIS) lecture, 28 April 1997, Longyearbyen, Svalbard, Norway.

Hall, D. K., "Development and testing of an algorithm to map global snow cover using satellite data," the Roald Amundsen seminar, sponsored by the Norwegian Polar Institute, 30 April 1997, Tromso, Norway.

Hall, D. K., J.L. Foster, A.T.C. Chang, C.S. Benson and J.Y.L. Chien, (poster presentation), "Determination of snow-covered area in different land covers in central

Alaska from aircraft data - April 1995," International Glaciological Society, 25 May, 1997, Chamonix, France.

Klein, A., Hall, D. K., Riggs, G.A, Improving snow-cover mapping in forests through the use of a canopy reflectance model, Eastern Snow Conference, Banff, Alberta, Canada.

**Attachments**

1) Hall, D. K., J.L. Foster, A.T.C. Chang, C.S. Benson and J.Y.L. Chien, in press: Determination of snow-covered area in different land covers in central Alaska from aircraft data - April 1995, Annals of Glaciology.

2) Klein, A., Hall, D. K., Riggs, G.A, Improving snow-cover mapping in forests through the use of a canopy reflectance model, submitted to Hydrological Processes.

3) Klein, A., Hall, D. K., Riggs, G. A., Improving the MODIS global snow-mapping algorithm, to appear in, Proceedings of IGARSS '97.

4) Scharfen, G. R., D.K. Hall and G.A. Riggs, MODIS snow and ice products from the NSIDC DAAC, to appear in, Proceedings of the SPIE Conference, 27 July - August 1, 1997, San Diego, CA.